AQUATIC MACROINVERTEBRATES OF "BRAY CREEK" AND "FROG ALLEY", TWO UNNAMED AGRICULTURAL DRAINAGES IN THE UPPER MACKINAW RIVER DRAINAGE: A FINAL REPORT

Prepared for

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INTRODUCTION

The Mackinaw River lies within the Grand Prairie Natural Division (Schwegman et al. 1973), is approximately 200 km long, and drains approximately 728,000 km^2 area in Tazewell, McLean, Woodford, Mason, Livingston, and Ford counties (IDNR 1997). While 66% of landuse in the basin is devoted to row crops, the land surrounding Panther Creek and the middle Mackinaw River northwest of Bloomington has been designated as a state Resource Rich Area (RRA) (IDNR 1996). This designation is based upon the river having a forested floodplain, the presence of 43.2 km of Biologically Significant Streams, several natural areas and preserves, and heritage sites located in the basin.

Efforts are ongoing to voluntarily enlist landowners in the basin to adopt better land management practices to maintain current levels of, and affect an improvement in, basin water quality, wildlife habitat, and regional biodiversity. The Nature Conservancy enlisted the help of the Illinois Natural History Survey (INHS), specifically Dr. R. Edward DeWalt of the Center for Biodiversity, to conduct pre- and post-management aquatic macroinvertebrate sampling, sample processing, and specimen identification in two unnamed tributaries of the Mackinaw River near Colfax, Illinois. The objective of this study is to quantitatively document the current species richness, biotic index values, and species relative proportions in one "control" and one "treatment" stream. This characterization will occur before and after the implementation of best management practices (BMP) in the treatment stream, in order to determine if BMPs have a significant effect on stream health, with aquatic macroinvertebrates being an index of health.

METHODOLOGY

Two streams were sampled at two locations each. One stream, an unnamed tributary of the Mackinaw River locally known as Frog Alley, constituted a control stream where presumably no changes in land use practices would occur over the life of the project. The treatment stream, again unnamed but locally referred to as Bray Creek, would undergo best management practices at locations above the downstream-most site. These were scheduled to take place after a two year pre-treatment time period. Minor BMPs have been instituted, the extent of which are unknown to the author. Site visits follow descriptions in Table1.

Table 1. Sampling events and progress in sample processing. X=samples collected, XX= macroinvertebrates sorted, XXX= macroinvertebrates identified and enumerated.

Sites↓ Dates→	May 1999	Dec 1999	May 2000	Dec 2000	May 2001	Nov 2001	May 2002	Nov 2002	May 2003	Nov 2003
Bray Creek, downstream	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX
Frog Alley, downstream	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX	XXX	XXX
Bray Creek, upstream	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX
Frog Alley, upstream	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XX	XXX	XXX

Riffles were chosen as the least variable and most easily sampled habitat in these streams. All streams had riffles. A Hess sampler, a cylinder with a screened entrance for water and a fine mesh net for exit of water and sample debris, was used to collect eight quantitative sample units from each stream site. These sample units were taken from riffles from throughout a 300-m reach, both above and below bridge access points. Sampling proceeded in an upstream fashion so as not to disturb macroinvertebrates during the sampling procedure. The Hess sampler placement occurred near the middle of riffles where current velocities were highest and substrates were coarsest. During fall 1999, a Surber sampler was used to collect samples. This is a rectangular net with a trailing mesh bag that permits sampling in shallow, flowing water. Mild-to-moderate drought reduced streams to a trickle at this time, necessitating the change in devise. Macroinvertebrates and sample debris were agitated to a depth of 10 cm from bottom substrates within the sampler. Coarse substrates were inspected individually to dislodge large and well-attached macroinvertebrates. Sample debris were transferred to appropriately labeled containers and preserved with enough 95% ethanol to yield an approximate 70% mixture.

Samples were generally large and densely populated, with a variety of macroinvertebrates. This density of organisms necessitated a 1/3 to 1/6 subsampling of all samples in order to maintain the projected budget costs established in the contract. A sample was placed in a tray and evenly distributed. Occasionally, the presence of long filamentous algae required the cutting of this material into short lengths that would more easily distribute. A tightly fitting plastic divider was used to produce subsample units. All materials were removed from that subunit and the invertebrates sorted and preserved. Sample abundance was then corrected for the subsample rate used.

Macroinvertebrate specimen identification was to the lowest possible taxonomic level, generally to genus, species groups, and in some cases species. The experimental design fits a Repeated Measures Analysis of Variance design with time and treatment as factors and species richness, biotic index values, proportions of functional feeding groups present, and the relative proportions of dominant taxa as dependent variables. The Hilsenhoff Biotic Index (HBI) was employed to provide an overall index of stream disturbance (Hilsenhoff 1987, Barbour et al. 1999). This index is calculated as a weighted average of taxon-specific tolerance values. Values range from 0 to 10 for each taxon, producing a scale of 0 to 10 for the overall index. A score of 10 indicates extreme disturbance and/or organic pollution, while lower values indicate a community in better condition.

Site Descriptions

Bray Creek (trib. 2, downstream site): IL: McClean Co.; unn. trib. Mackinaw R. (Bray Cr.), 2 km SSW Colfax @ Co.-Rd. 1800N; 40.5440 N Lat. –88.6267 W Long. This is an agricultural drainage, channelized, 3-5 m wide, once ditched, and cleared of most trees. This drainage has been in this condition for many decades. The riparian zone consists of a 60-ft grass buffer with scattered trees. The stream has a moderately fast flow in the spring, and usually maintains flow even in drought years. Substrate is coarse with gravel and cobble fractions providing approximately 70% of total. Sand contributed the remainder. The stream provides adequate habitat for fish and invertebrates with undercut banks, pools of varied depth, with interstices of coarse substrates providing refugia. Levees had been built up by dredging long ago. Stream banks were remarkably stable for being cut so steeply. This stream has good potential for a rapid response to improvements in management. Tree planting would return the balance of nutrient sources to an allochthanous basis.

Frog Alley (Tributary 3, downstream): IL: McLean Co., Unn. trib. Mackinaw River (Frog Alley) @ Co.-Rd. 1800N, 6 km ESE Colfax. 40.5436 N Lat. -88.5017 W Long. This too is an agricultural drainage, 3 to 5-m wide, channelized, ditched, and cleared of all trees. Riparian zone is grass about <10 m wide on both sides. The stream has a moderately fast flow in the spring with slower, sometimes intermittent, flows in the fall and winter. Substrates are finer than downstream Bray Creek, with sand contributing over 50% of the total. The stream provides less than adequate habitat for fish and invertebrates due to the absence of undercut banks and pools of varied depth. Levees had been built up by dredging. Stream banks were less stable than at the Bray Creek downstream site, as evidenced by the bank failure in several locations. Sand deposition resulted due to this bank failure. Overall, this site demonstrated poorer habitat quality than found at the Bray Creek downstream site.

Frog Alley (trib. 3, upstream): IL: McClean Co., 6 km SE Colfax, Co.-Rd. 1600N; 40.5149 N Latitude, 88.6057 W Longitude. Again, an agricultural drainage, 1 to 2-m wide, largely cleared of trees, but not ditched or channelized. The riparian zone is in cattle pasture, not now in use, that is about 10-m wide on least buffered side. The landowner regularly burns this area. The stream has a moderately fast flow in the spring, but has dried to isolated pools in the fall and winter. Substrates are coarse with gravel and cobble fractions providing approximately 70% of total. The stream provides adequate habitat for fish and invertebrates with undercut banks, pools of varied depth, and interstices of coarse substrate providing refugia. Bank structure was natural without the deep channels seen at other sites. This stream has good potential for a rapid response to improvements in management. Tree planting would return the balance of nutrient sources to an allochthanous basis and allow for greater water storage during flooding.

Bray Creek (trib. 2, upstream site): IL: McClean Co., 7 km SSW Colfax, Co.-Rd. 1600N; 40.5153 N Latitude, 88.6588 W Longitude. This stream is 2 to 3-m wide, cleared of trees, ditched and channelized. The Riparian zone is cattle pasture that is about 15-m wide on both sides of the stream. Cattle are fenced into this stream levee and bank slope, which results in deep ruts in the slopes and broken bank structure. Cattle wastes were abundant on the slopes and in the channel. Substrates were the finest grained of all sites with sand and silt contributing approximately 70% of total, and overlying original coarser substrates. The stream provided little habitat for fish and invertebrates due to the broken banks and fine, unstable substrates. Exclusion of cattle from the drainage, bank stabilization, and planting of trees will be necessary to rehabilitate this stream.

RESULTS

Aquatic Macroinvertebrate Abundance

A subsample adjusted 420,825 specimens have been examined throughout the life of the project (Table 2). Total abundance from Table 2 demonstrates that downstream, larger sites supported a greater abundance than did upstream locations. In this regard, upstream sites were not appreciably different from each other. Mean abundance of macroinvertebrates for fall samples (Fig. 1A) demonstrated year in which the samples were taken was an important factor in determining abundance. It is quite possible that drought is the proximate cause this difference. 1999 samples for all sites had much greater abundances than found in 2000 (a severe drought year) and were largely higher than that found in 2001 as well. Some recovery seems to have taken place in 2002 and 2003, but not are samples are completely processed for this time frame, so conclusions are not warranted.

Spring abundances (Fig. 1B) also presumably show an effect of drought, with the same years showing declines and improvements, but with 2002 still showing the effects of drought. Drought in this year broke toward late summer and into the fall.

Macroinvertebrate Species Richness

One hundred forty-five taxa (at a variety of taxonomic resolutions) were identified over the life of the project (Table 2). All sites supported at or over 100 total taxa, with the exception of upstream Frog Alley, which supported about 10% fewer taxa. Project total Ephemeroptera + Plecoptera + Trichoptera species richness (EPT taxa) also varied little, with the exception of upstream Frog Alley. This site supported only about 60% of the EPT taxa identified from the other sites. At all but the upstream Frog Alley site, mayflies provided the bulk of the EPT species in all cases. Most of the mayflies were baetids (small minnow mayflies) with short life cycles and good dispersal abilities. Upstream Frog Alley EPT richness had caddisflies as the greatest component. This site is the most intermittent of all sampled locations, which has undoubtedly contributed to its different faunal assemblage and diversity.

Mean fall total taxa richness (Fig. 2A) varied similarly to that of abundance, with greater richness values during years of greater stream flow. Downstream sites, those with more water, fluctuated less so than did upstream sites, which in the years 2000 and 2001 experienced greatly reduced flows. Spring samples (Fig. 2B) varied less overall and had generally greater richness values than found in corresponding years in fall samples. Generally, the driest time of the year in the region is late summer and fall, not winter and spring. However, the 2002 spring samples showed dramatic total taxa richness declines that corresponded well with reduced abundances (Fig. 1B). The winter and spring of 2003 was wet, contributing to a rebound in total taxa richness then.

Mean fall EPT richness (Fig. 3A) was highest for downstream Frog Alley in every year. Generally, the lowest average values were found at upstream Frog Alley. Again, drought in the years 2000 and 2001 appeared to decrease richness of EPT, with an improvement in 2003. However, some data are not yet ready for evaluation and conclusions for this season are still tentative.

Mean spring EPT richness (Fig. 3B) varied much less across sites and years than did fall EPT richness. It appears that only the year 2002 demonstrated an affect of drought, which closely followed the loss of abundance in the same year (Fig. 1B). Downstream sites had slightly higher average EPT richness values than did upstream sites.

Hilsenhoff Biotic Index

This index of organic pollution was developed by Hilsenhoff (1987) and has a scale that runs from zero to 10, with 10 being a stream of high enrichment--degradation. It has been found to be not very sensitive within the confines of Illinois, as most of our stream condition problems are due to habitat related factors, not organic enrichment. However, on this scale, it was thought to be potentially useful.

Fall HBI values (Fig. 4) did not vary widely across sites and years, but upstream Bray Creek was consistently the highest scoring site. This is not surprising because of the cattle fenced into the bank slope at this site. Generally, the effects of organic enrichment are less in colder times of the year due to the lower respiration of microbes (they are ectotherms) that metabolize organic substrates.

Spring HBI values (Fig. 4B) varied much more than did fall values and generally had higher scores than were found for fall, indicative of moderate organic enrichment and/or disturbance. Upstream Frog Alley consistently had the lowest (best) scores, indicating that its fauna was dominated by species intolerant of organic enrichment.

Dominance

Thirteen taxa had overall abundances at or over 5,000 individuals (Table 2). The most abundant taxon was the chironomid midge, *Cricotopus/Orthocladius* sp., contributing >95,000 specimens. This is a complex of genera and species that cannot be readily determined in the larval stage, and that is thought to function as a collector-gather of fine particles and scraper of algae. The clear, nutrient rich waters contribute to large blooms of bacteria, fungi, and algae, providing a rich food source. The next most abundant taxon, the stonefly *Allocapnia vivipara*, functions as a shredder of leaves and as a collector-gatherer. This species is restricted to November through March; hence, it only shows up in the fall samples—all the more remarkable for its abundance. *Stenelmis* prob. *sexlineata* (99% of all adult elmid beetles were this species) was also very abundant with over 36,000 larvae and adults. This is a scraper of algae, utilizing the abundant algal grow to amass its large numbers. Another abundant species was the mayfly *Caenis latipennis*. *Helicopsyche borealis* was another abundant scraper. The only predator to reach this threshold of abundance was the stonefly *Isoperla nana*, which actually may function more as an herbivore during its early instars in fall and winter.

Collector-gatherers, grazers, dominated the macroinvertebrate assemblage. These included large numbers of the chironomid midge *Cricotopus/Orthocladius* spp., the riffle beetle *Stenelmis sexlineata*, and the baetid mayfly *Plauditus* sp. These taxa benefit from the lack of canopy cover and nutrient enrichment that promote lush algal growth characteristic of agricultural drainages. A unique fauna occurred at upstream Frog Alley, where the perlodid stonefly *Isoperla nana* contributed 100-300 individuals per sample. The abundance of this taxon here is one-to-two orders of magnitude greater than at the other locations (Table 2).

DISCUSSION

These stream reaches are generally commensurate with a highly disturbed, agricultural landscape that is often subject to mild to moderate drought conditions. Both drainages are tiled to improve drainage, which undoubtedly contributes the severity of drought. It appears that drought is more detrimental on the fall communities than during the spring, as the former usually follows a period of lower rainfall in late summer and fall months.

Some differences between sites were apparent in mean abundance and EPT richness, most notably the downstream locations have greater abundance and taxa richness. The upstream Frog Alley location produced a unique faunal assemblage, possibly owing to its small size and frequent intermittency.

LITERATURE CITED

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Hilsenhoff, W. L. 1987. An improved index of organic stream pollution. Great Lakes Entomologist. 20:31-39.

IDNR. 1996. Critical Trends Assessment Project, Phase II, Inventory of Resource Rich Areas in Illinois. Illinois Department of Natural Resources. 167 pp.

IDNR. 1997. Mackinaw River Area Assessment, Volume 2. Illinois Department of Natural Resources, Critical Trends and Assessment Program. 229 pp.

Schwegman, J. E. 1973. Comprehensive Plan for the Illinois Nature Preserves System, Part 2, The Natural Divisions of Illinois. Illinois Nature Preserves Commission. 32 pp.

FIGURE LEGENDS

Fig. 1. Mean abundance of macroinvertebrates from four Mackinaw River headwater stream sites collected spring 1999 through all 2003. A) Fall results, B) Spring results.

Fig. 2. Mean total taxa richness of macroinvertebrates from four Mackinaw River headwater stream sites collected spring 1999 through all 2003. A) Fall results, B) Spring results.

Fig. 3. Mean Ephemeroptera+Plecoptera+Trichoptera (EPT) richness of macroinvertebrates from four Mackinaw River headwater stream sites collected spring 1999 through all 2003. A) Fall results, B) Spring results..

Fig. 4. Mean Hilsenhoff Biotic Index (HBI) of macroinvertebrates from four Mackinaw River headwater stream sites collected spring 1999 through all 2003. A) Fall results, B) Spring results.

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Table 2. Taxa Collected from Bray Creek and Frog Alley in McClean Co. at county roads 1600N (UP=Upstream) and 1800N (DN=Downstream) from May 1999 to November 2003. Numbers reflect those corrected from subsample rates.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
Coelenterata	Hydridae	Hydra	sp.	20	21	229	15	285
Platyhelminthes								
	Planaridae	Dugesia	tigrina	189	0	0	0	189
Nematoda	Nematoda	Nematoda	sp.	954	1963	629	1401	4947
Nematomorpha	Gordiidae	Gordius	sp.	28	50	28	4	110
Annelida								
Rhynchobdellida	Glossophonidae	Placobdella	montifera	0	0	0	2	2
		Placobdella	ornata	0	3	0	0	3
	Piscicolidae	Piscicolidae	sp.	1	0	0	0	1
Mollusca								
Bivalvia								
Veneroidea	Sphaeriidae	Pisidium	sp.	62	0	0	0	62
		Sphaeriidae	sp.	13	0	0	0	13
		Sphaerium	sp.	8	0	0	0	8
Gastropoda								
Basomatophora	Ancylidae	Ferrissia	sp.	8	55	0	715	778
	Lymnaeidae	Lymnaeidae	sp.	8	10	18	23	59
	Physellidae	Physella	sp.	73	37	83	137	330
Megagastropoda	Hydrobiidae	Hydrobiidae	sp.	16	0	0	0	16
Arthropoda				0	0	0	0	0
Crustacea				0	0	0	0	0
Amphipoda	Cragonyctidae	Synurella	sp.	0	0	0	6	6
	Gammaridae	Gammarus	sp.	0	0	8	3	11
	Talitridae	Hyallela	azteca	0	0	6	0	6
Decapoda	Cambaridae	Orconectes	virilis	6	0	0	0	6
		Cambaridae	sp.	0	1	0	6	7
		Cambarus	sp.	0	4	0	4	8
Arachnida								
Hydracarina	Hydracarina	Hydracarina	sp.	9953	0	3012	63	13028
Insecta								
Coleoptera	Dryopidae	Helichus	fastigiatus	0	0	0	4	4

Table 2. Continued.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
Coleoptera	Dryopidae	Helichus	striatus	0	0	0	9	9
	Dytiscidae	Agabus	sp.	6	28	47	39	120
	Dytiscidae	Liodessus	sp.	0	12	0	0	12
	Dytiscidae	Neoporus	sp.	0	6	0	2	8
	Dytiscidae	Dytiscidae	sp.	4	0	0	8	12
	Elmidae	Dubiraphia	minima	8	0	0	0	8
	Elmidae	Dubiraphia	quadrinotata	0	0	4	0	4
	Elmidae	Dubiraphia	sp.	1107	544	1291	305	3247
	Elmidae	Macronychus	glabratus	3	0	0	3	6
	Elmidae	Stenelmis	crenata	1	6	0	10	17
	Elmidae	Stenelmis	grossa	0	0	8	0	8
	Elmidae	Stenelmis	sexlineata	1084	649	2517	352	4602
	Elmidae	Stenelmis	sp.	9365	6890	6577	3224	26056
	Haliplidae	Peltodytes	sp.	0	0	0	3	3
	Hydrophilidae	Berosus	aculeatus	0	0	1	0	1
	Hydrophilidae	Berosus	sp.	135	9	341	0	485
	Hydrophilidae	Hydrophilidae	sp.	0	2	0	0	2
Diptera	Ceratopogonidae	Atrichopogon	sp.	0	0	0	4	4
		Ceratopogon	sp.	27	38	888	120	1073
		Culicoides	sp.	232	462	641	239	1574
		Probezzia	sp.	1746	2009	642	1777	6174
		Ceratopogonidae	sp.	4	0	0	0	4
	Chironomidae	Brillia	flavifrons	1	0	0	21	22
		Chironomus	riparius	0	6	24	186	216
		Chironomus	sp.	0	4	73	0	77
		Cladotanytarsus	sp.	2011	4473	8973	116	15573
		Clinotanypus	sp.	0	4	0	0	4
		Conchapelopia	sp.	1127	1535	1544	371	4577
		Corynoneura	sp.	34	10	2	10	56
		Cricotopus	bicinctus	58	246	43	22	369
		Cricotopus	trifasciagrp	192	19	22	4	237
		Cricotopus_Orthoclad	sp.	32224	14550	22471	26095	95340

Table 2. Continued.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
Diptera	Chironomidae	Cryptochironomus	fulvusgrp	425	568	446	36	1475
		Cryptotendipes	sp.	0	36	0	0	36
		Diamesa	sp.	22	24	86	175	307
		Dicrotendipes	fumidus	474	648	2331	43	3496
		Diplocladius	cultriger	12	18	6	40	76
		Endochironomus	sp.	4	2	2	0	8
		Eukiefferiella	brehmigrp	30	4	4	0	38
		Eukiefferiella	brevicalcargrp	1	85	875	2097	3058
		Eukiefferiella	claripennisgrp	1	221	1354	1102	2678
		Eukiefferiella	sp.	31	12	14	18	75
		Glyptotendipes	sp.	10	0	0	12	22
		Hydrobaenus	sp.	221	691	1529	2120	4561
		Krenopelopia	sp.	0	2	8	0	10
		Labrundinia	pilosella	3	0	0	0	3
		Larsia	sp.	263	10	138	0	411
		Limnohyphes	sp.	19	36	70	1401	1526
		Microtendipes	pedellusgrp	417	3214	3107	13	6751
		Nanocladius	sp.	13	24	9	2	48
		Natarsia	sp.a	0	0	0	24	24
		Nilotanypus	fimbriatus	6	16	0	0	22
		Orthocladiinae	sp.	8	3	48	6	65
		Orthocladius	annectens	24	30	3	9	66
		Parachironomus	sp.	3	6	23	2	34
		Paracladopelma	sp.	4	0	0	0	4
		Parakiefferiella	sp.a	4932	4292	4345	1545	15114
		Paralauterborniella	nigrohalteralegrp	1	0	0	0	1
		Parametriocnemus	sp.	82	75	74	298	529
		Paraphaenocladius	sp.	0	6	0	0	6
		Paratanytarsus	sp.	557	1179	416	137	2289
		Paratendipes	albimanus	0	0	12	25	37
		Paratendipes	subaequalis	80	62	152	10	304
		Paratendipes	sp.	4	18	42	9	73

Table 2. Continued.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
Diptera	Chironomidae	Phaenopsectra	obediensgrp	6	4	0	2	12
		Polypedilum	flavum	2016	3260	642	486	6404
		Polypedilum	illinoense	50	90	0	31	171
		Polypedilum	fallax	0	4	0	0	4
		Polypedilum	halteralegrp	0	57	18	18	93
		Polypedilum	ontario	6	0	0	0	6
		Polypedilum	scalaenumgrp	3	129	10	0	142
		Polypedilum	sp.	0	4	4	0	8
		Psectrocladius	sp.	0	0	23	8	31
		Pseudochironomus	sp.	271	433	291	0	995
		Pseudosmittia	sp.	0	12	37	12	61
		Rheocricotopus	sp.	227	438	101	198	964
		Rheopelopia	sp.	477	722	472	178	1849
		Rheotanytarsus	sp.	629	1022	1984	122	3757
		Saetheria	sp.	0	6	4	0	10
		Smittia	sp.	0	0	8	44	52
		Stictochironomus	sp.	69	737	778	69	1653
		Tanypus	neopunctipennis	0	0	1	0	1
		Tanytarsus	sp.	1438	5361	6351	1527	14677
		Thienemanniella	xena	110	98	242	300	750
		Thienemanniella	sp.a	0	0	0	1	1
		Tribelos	sp.	0	4	8	0	12
		Zavrelimyia	sp.	0	0	0	12	12
		Chironomidae	sp.	385	242	222	0	849
	Culicidae	Culicidae	sp.	0	0	6	0	6
	Empididae	Hemerodromia	sp.	0	1479	591	127	2197
	Ephydridae	Ephydridae	sp.	0	10	0	11	21
	Muscidae	Muscidae	sp.	562	58	20	110	750
	Pscychodidae	Psychodidae	sp.	0	0	0	4	4
	Simuliidae	Simulium	sp.	1	990	882	1215	3088
	Stratiomyidae	Stratiomys	sp.	0	6	2	3	11
	Tabanidae	Chrysops	sp.	10	12	4	6	32

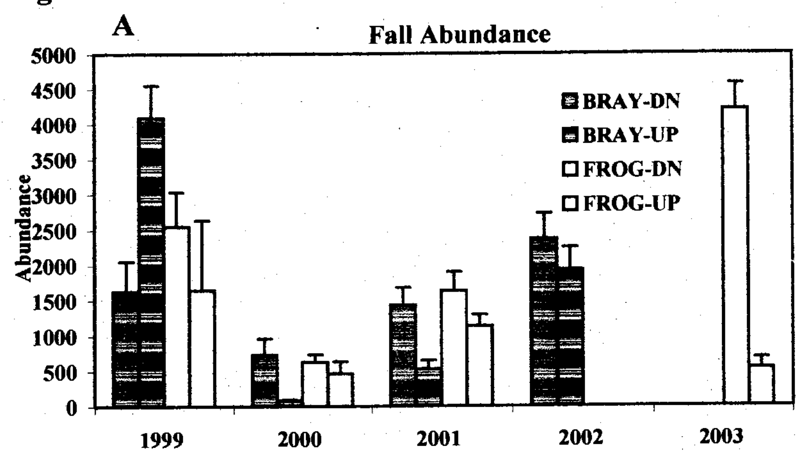
Table 2. Continued.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
	Tabanidae	Tabanus	complex	1039	6	16	1	1062
	Tipulidae	Antocha	sp.	0	0	6	0	6
		Dicranota	sp.	58	0	2	4	64
		Eriopterini	sp.	0	6	12	0	18
		Hexatoma	sp.	0	6	0	6	12
		Limonia	sp.	2	30	8	24	64
		Ormosia	sp.	48	2	152	5	207
		Pericoma	sp.	8	33	26	142	209
Diptera	Chironomidae	Pseudolimonia	sp.	2	4	0	0	6
		Tipula	sp.	7	84	117	2	210
		Tipulinae	sp.	10	6	0	0	16
Ephemeroptera	Baetidae	Acentrella	turbida	99	78	37	0	214
		Acerpenna	pygmaea	681	908	3295	229	5113
		Baetis	flavistriga	91	408	333	135	967
		Baetis	intercalaris	901	2	13	0	916
		Plauditus	sp.	6	696	4118	2433	7253
		Pseudocloeon	sp.	0	6	2	0	8
	Caenidae	Caenis	latipennis	12549	14922	9086	238	36795
	Ephemeridae	Hexagenia	sp.	0	10	32	0	42
	Heptageniidae	Heptageniidae	sp.	12	5	68	5	90
		Leucrocuta	hebe	0	0	12	0	12
		Leucrocuta	sp.	3	0	128	0	131
		Stenacron	interpunctatum	1328	254	851	61	2494
		Stenonema	terminatum	4	0	0	0	4
	Isonychiidae	Isonychia	sp.	0	0	6	0	6
	Leptohyphidae	Tricorythodes	sp.	58	0	6	0	64
	Leptophlebiidae	Paraleptophlebia	praepedita	6	3562	0	0	3568
Odonata	Coenagrionidae	Argia	sp.	104	24	1	0	129
		Enallagma	sp.	12	30	16	2	60
		Coenagrionidae	sp.	0	4	0	0	4
	Gomphidae	Dromogomphus	sp.	6	0	24	0	30
		Gomphidae	sp.	0	1	0	0	1

Table 2. Continued.

Phylum Class Order	Family	Genus	Species	Bray-DN	Bray-UP	Frog-DN	Frog-UP	Totals
Odonata	Libellulidae	Libellula	sp.	0	12	0	0	12
Plecoptera	Capniidae	Allocapnia	vivipara	7938	3825	28698	22482	62943
	Perlidae	Perlesta	sp.	34	6	32	0	72
	Perlodidae	Isoperla	nana	309	173	2051	10041	12574
	Taeniopterygidae	Taeniopteryx	burksi	12	12	7	0	31
Trichoptera	Helicopsychidae	Helicopsyche	borealis	4970	460	4524	4	9958
	Hydropsychidae	Cheumatopsyche	pettiti	19	10	4	0	33
		Cheumatopsyche	sp.	1093	2804	2315	2710	8922
		Hydropsyche	betteni	56	0	78	6	140
	Hydroptilidae	Hydroptila	ajax	0	6	14	0	20
Trichoptera	Hydroptilidae	Hydroptila	angusta	51	4	6	0	61
		Hydroptila	sp.	2089	1222	1241	15	4567
	Leptoceridae	Ceraclea	sp.	6	6	14	9	35
		Oecetis	sp.	4	21	33	3	61
		Oecetis	inconspicua	0	0	3	0	3
	Philopotamidae	Chimarra	obscura	35	6	6	0	47
	Phryganeidae	Ptilostomis	sp.	0	12	10	0	22
			Individuals	108265	89772	135320	87468	420825
			Ephemeroptera	11	10	12	5	14
			Plecoptera	4	4	4	2	4
			Trichoptera	7	7	9	6	9
			EPT	22	21	25	13	27
			Total Taxa	104	109	103	95	145

Fig. 1


A
Fall Abundance
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Abundance
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
1999
2000
2001
2002
2003

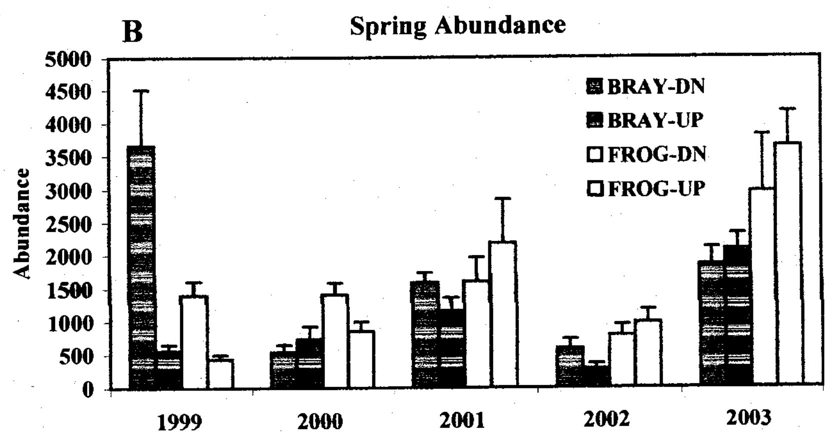

B
Spring Abundance
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Abundance
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
1999
2000
2001
2002
2003

Fig. 2

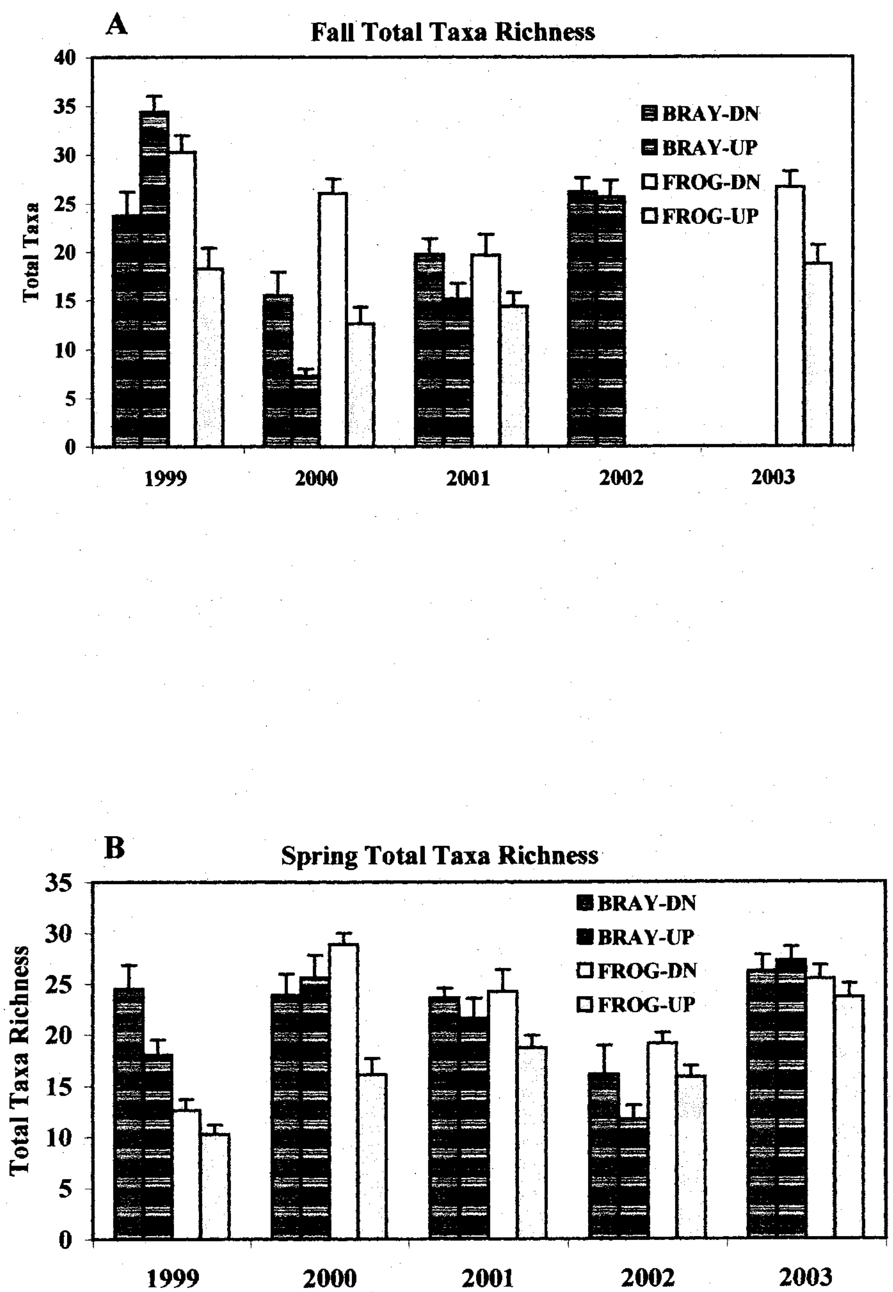
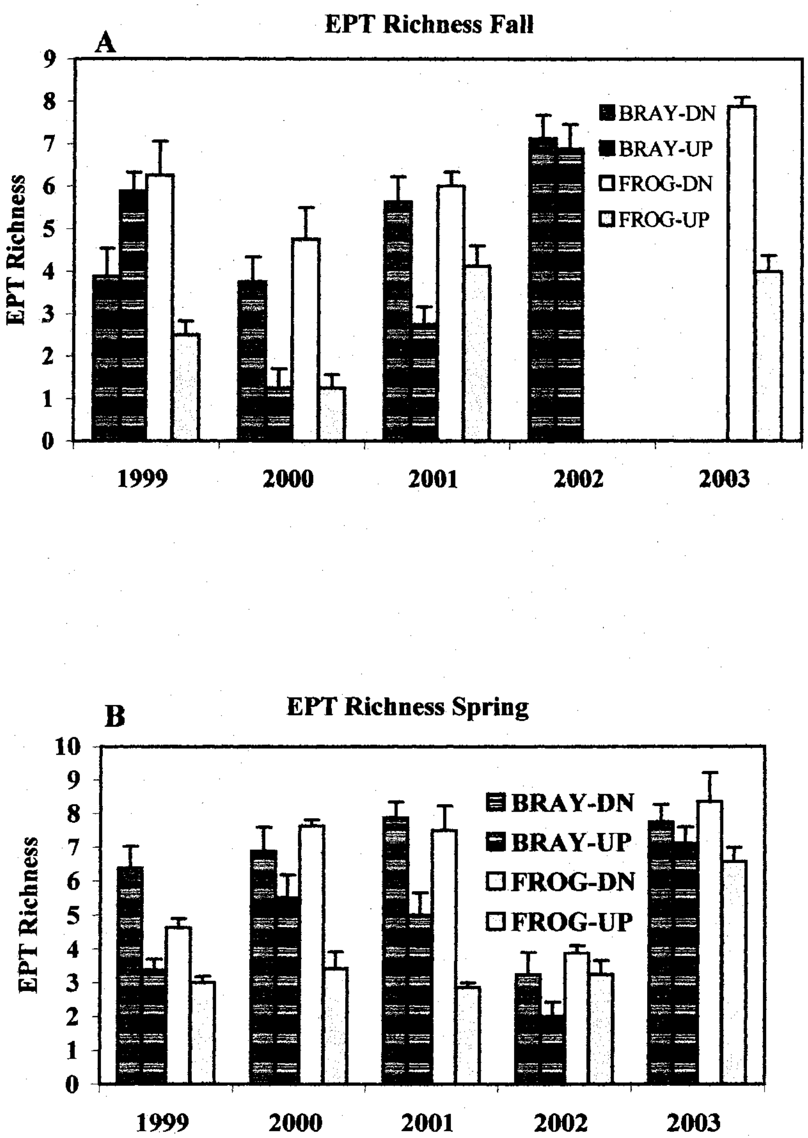
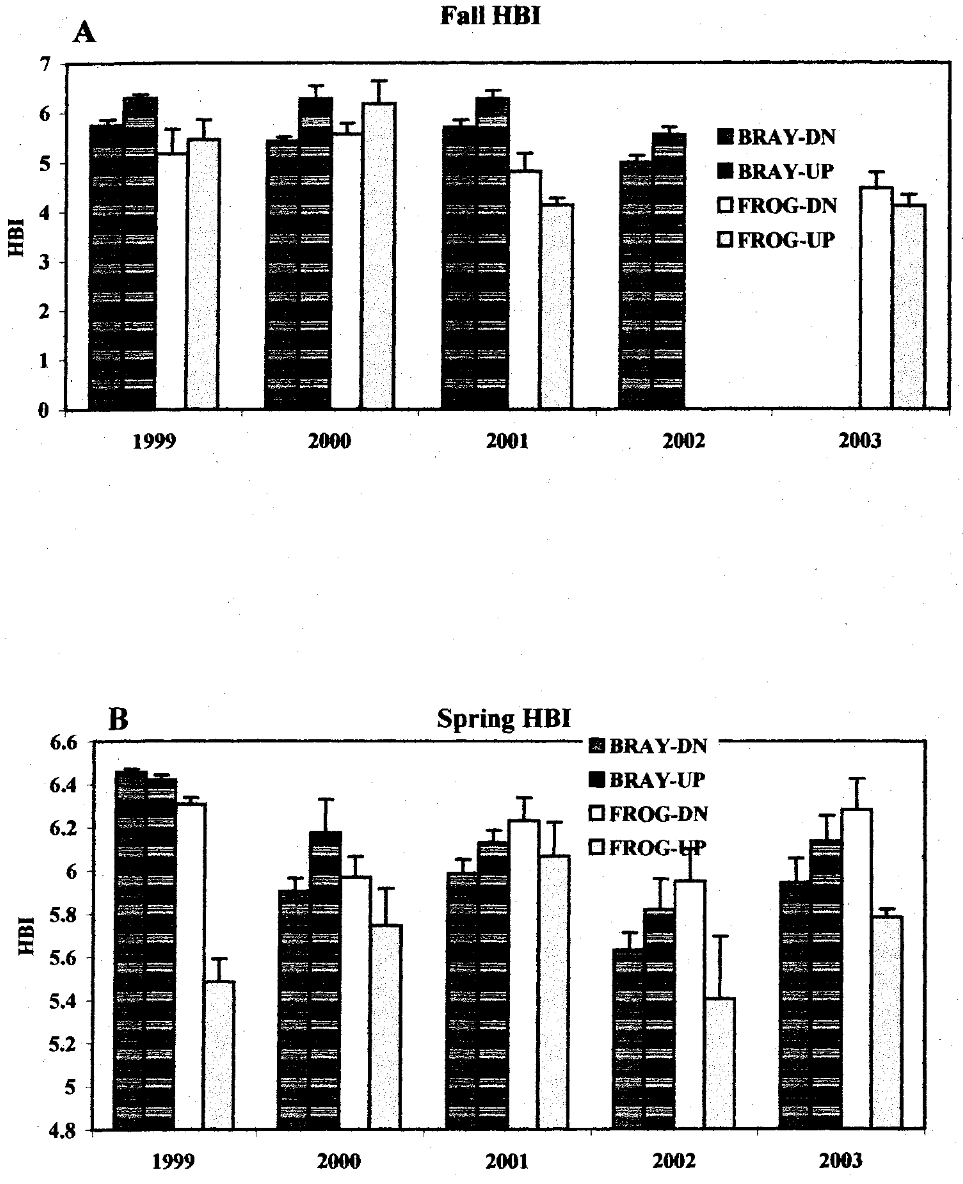

A
Fall Total Taxa Richness
Total Taxa
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
0
5
10
15
20
25
30
35
40
1999
2000
2001
2002
2003
B
Spring Total Taxa Richness
Total Taxa Richness
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
0
5
10
15
20
25
30
35
1999
2000
2001
2002
2003

Fig. 3



A
EPT Richness Fall
EPT Richness
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
0
1
2
3
4
5
6
7
8
9
1999
2000
2001
2002
2003
B
EPT Richness Spring
EPT Richness
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
0
1
2
3
4
5
6
7
8
9
10
1999
2000
2001
2002
2003

Fig. 4


A
Fall HBI
HBI
7
6
5
4
3
2
1
0
1999
2000
2001
2002
2003
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP
B
Spring HBI
HBI
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
4.8
1999
2000
2001
2002
2003
BRAY-DN
BRAY-UP
FROG-DN
FROG-UP